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(54) Abstract Title
A vehicle braking system permitting collapse of the pedal upon collision

(57) A vehicle brake system comprising a vehicle wheel brake operated by a brake pedal 10 connected to means permitting the pedal to collapse against a controlled force in the event of a vehicle collision while maintaining a level of braking. In Fig.1, the brake pedal 10 is connected to the push rod 20 of a servo 22 through an intermediate member 17 pivoted on the pedal shaft 16 and a coil spring. The pedal 10 moves relative to the member 17 against the resilience of spring 36 when subject to a depressing force exceeding a limiting value. In Fig.2 (not shown), the resilient force is produced by Belleville washers, in Fig.3 (not shown) by a helical spring, in Fig.6 by a brake pressure relief hydraulic accumulator moving a piston biassed by compressed nitrogen in a cylinder, and in Fig.7 (not shown) by gas struts.

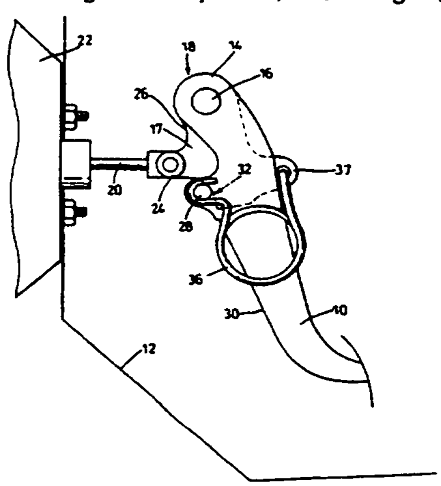

Fig. 1

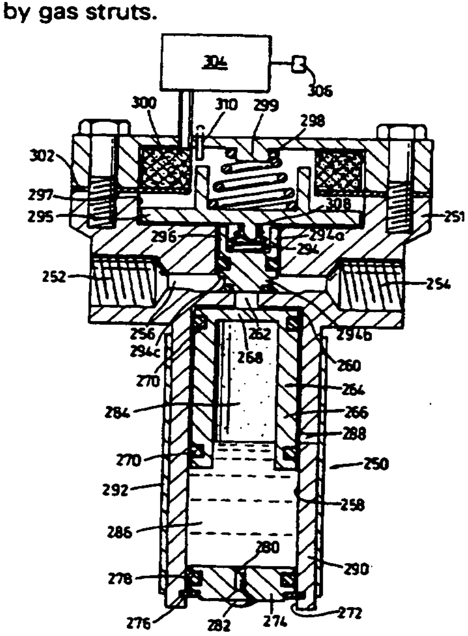

Fig. 6

At least one drawing originally filed was informal and the print reproduced here is taken fr m a later filed formal copy.

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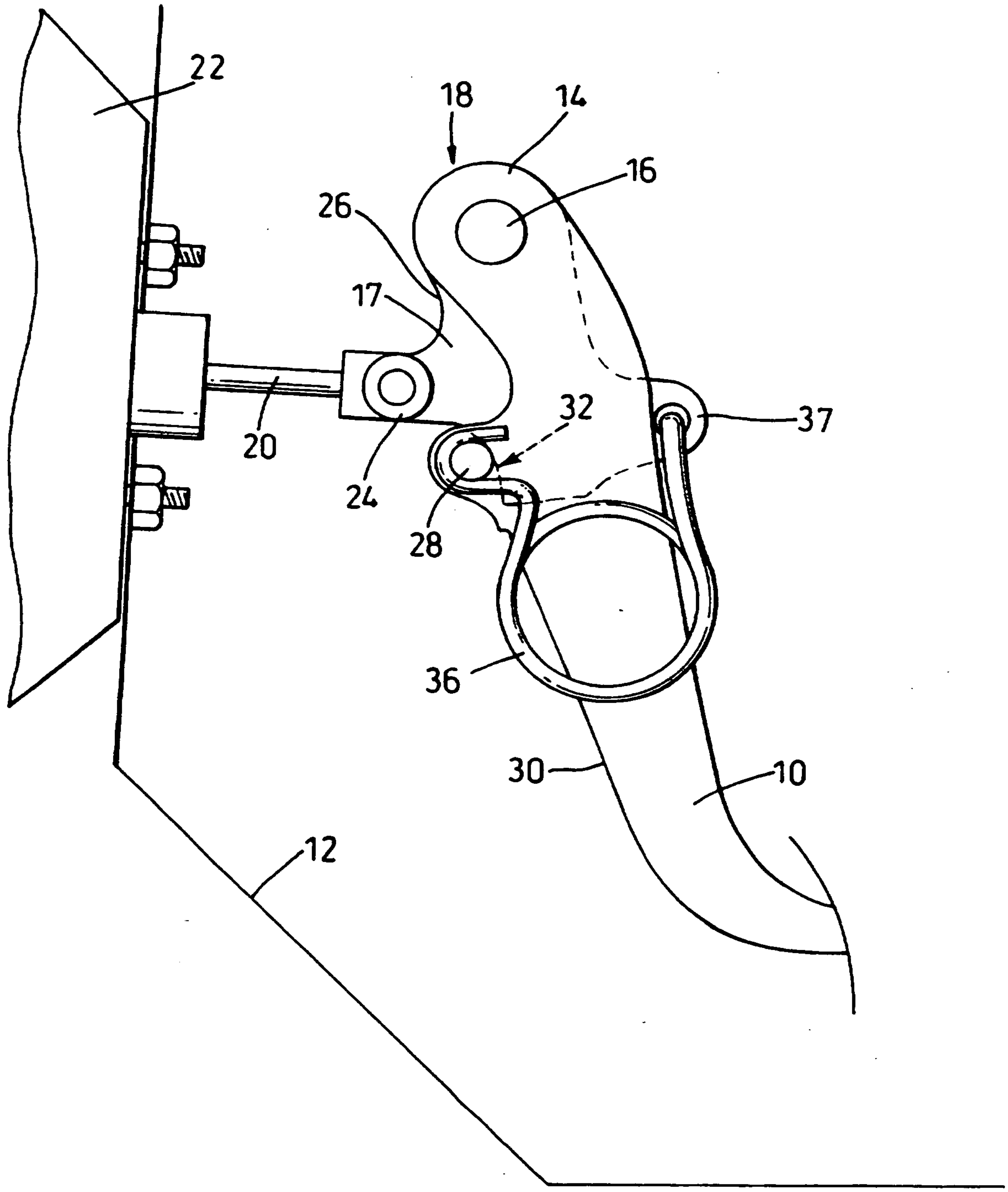

Fig 1

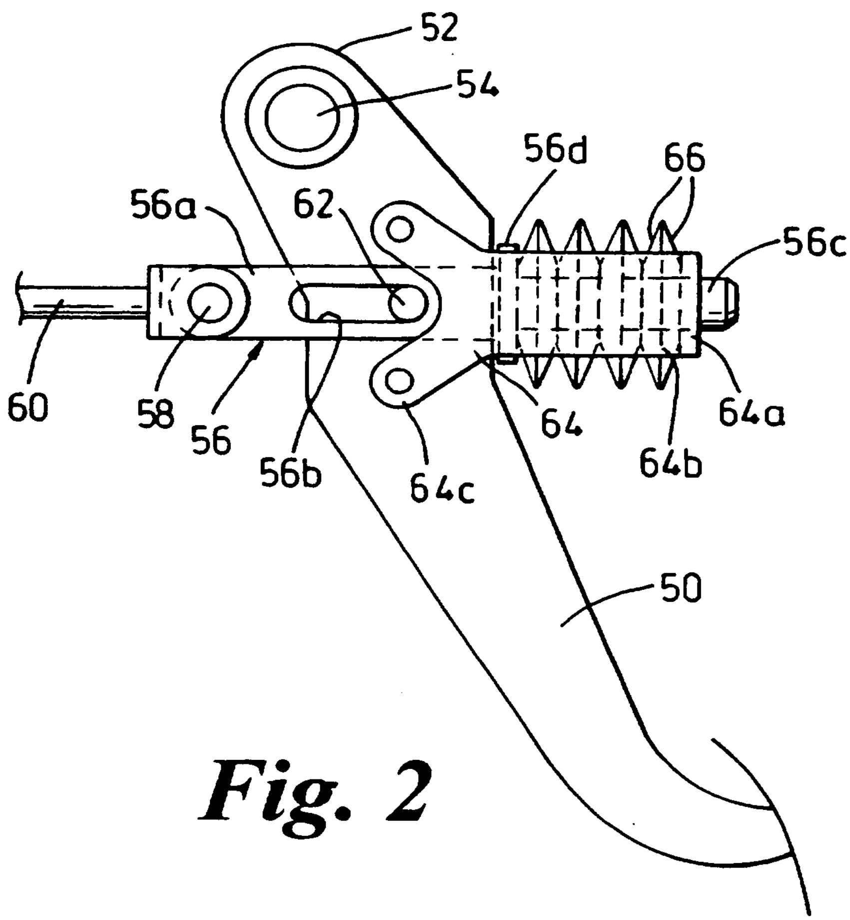
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Fig. 2

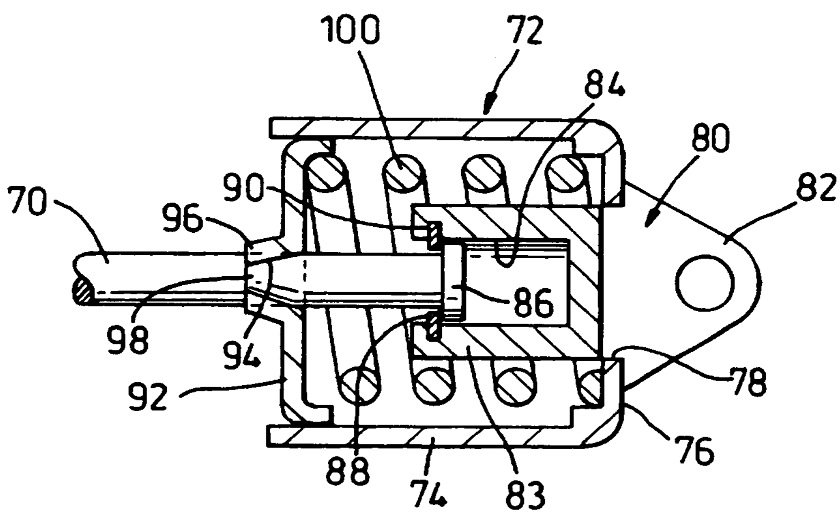
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Fig 3

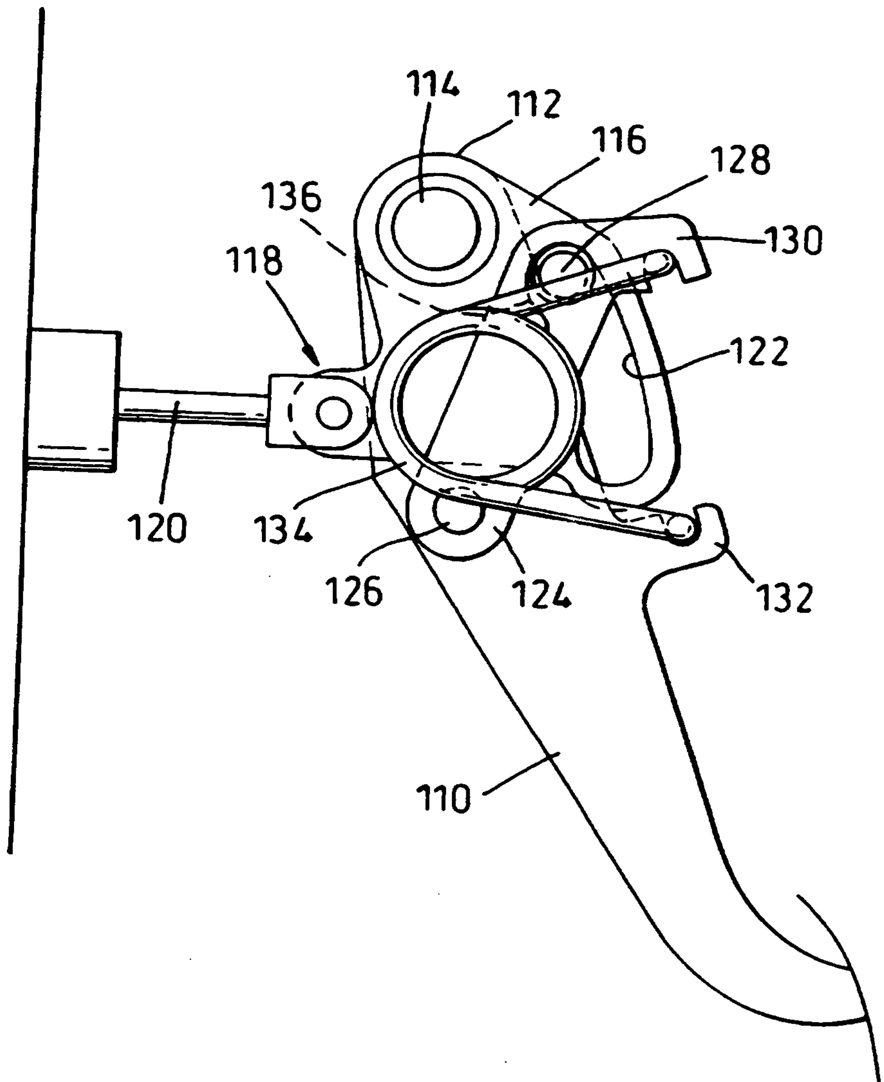

Fig 4

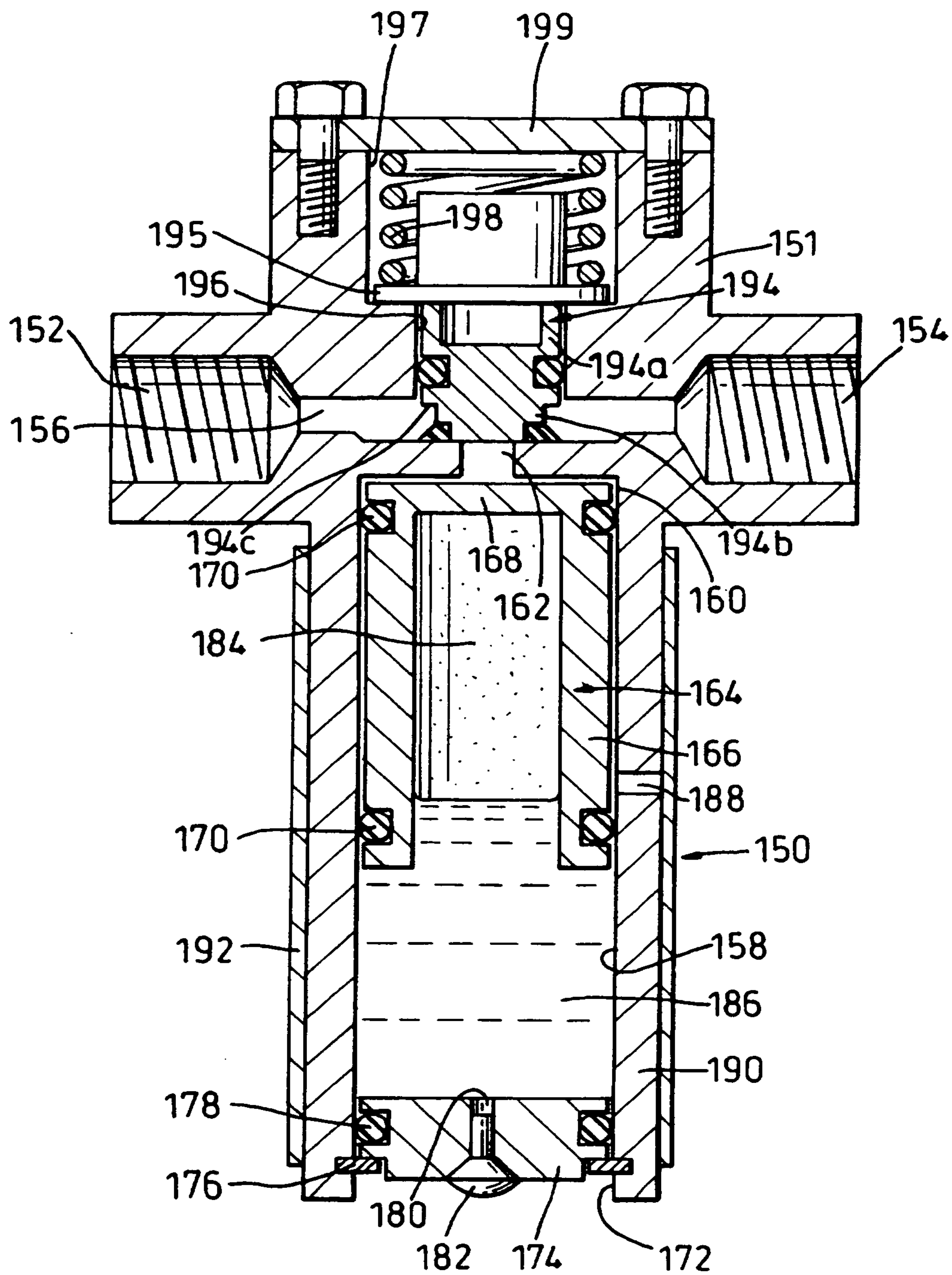
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Fig 5

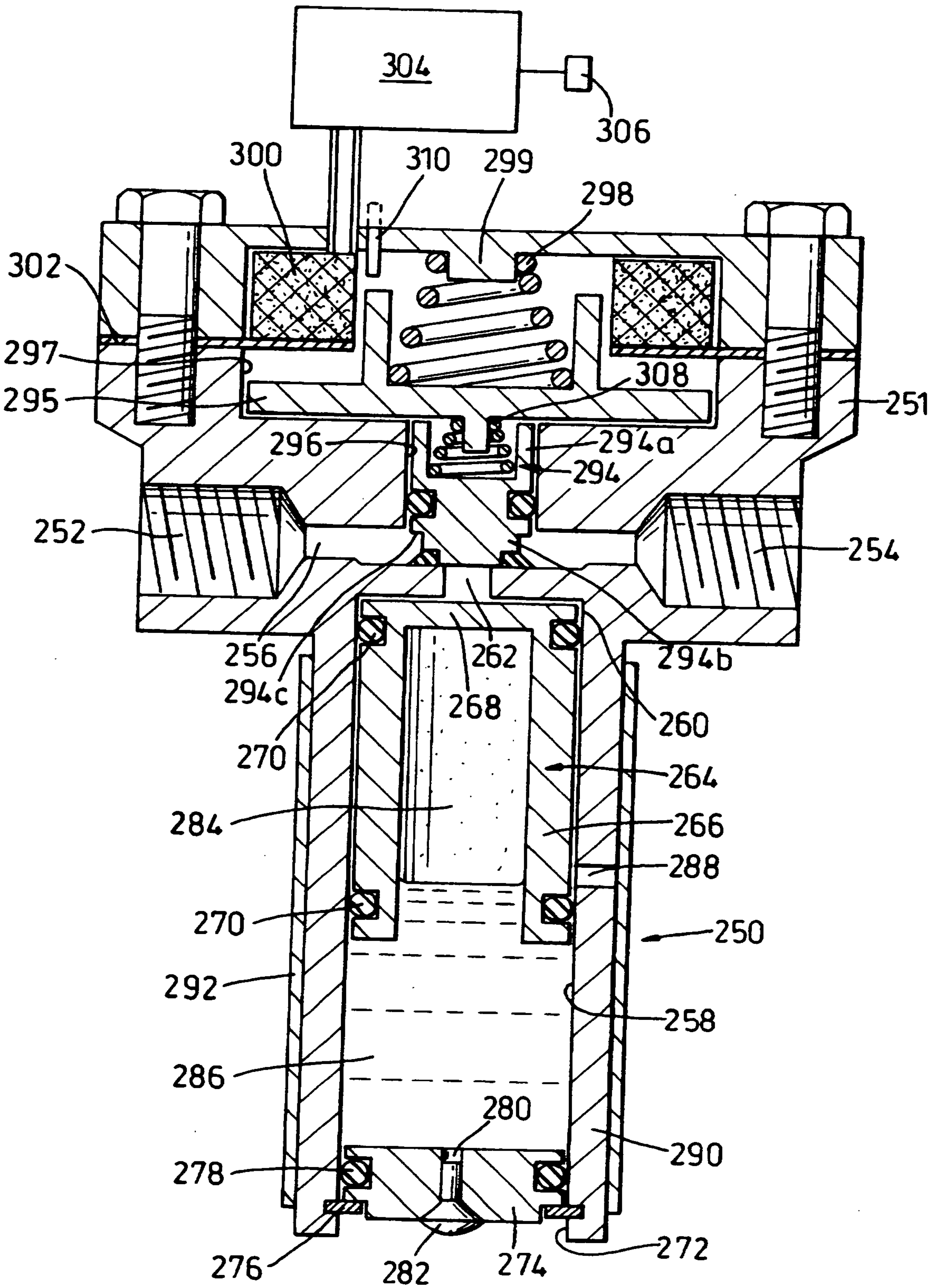
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Fig 6

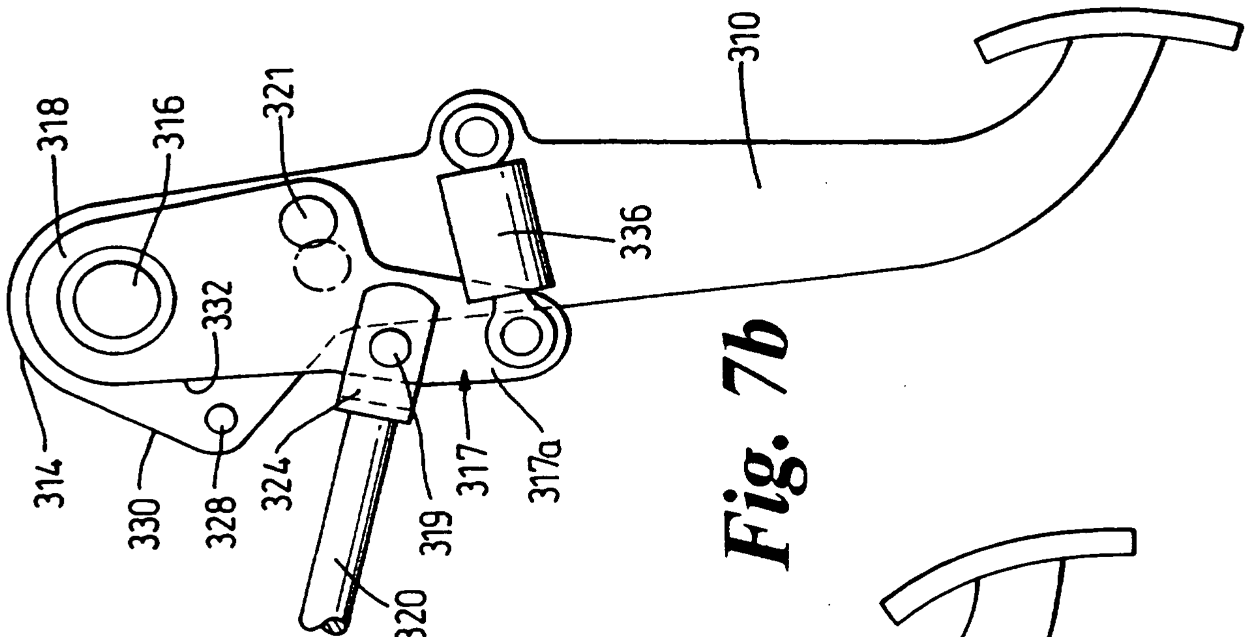

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Fig. 7b

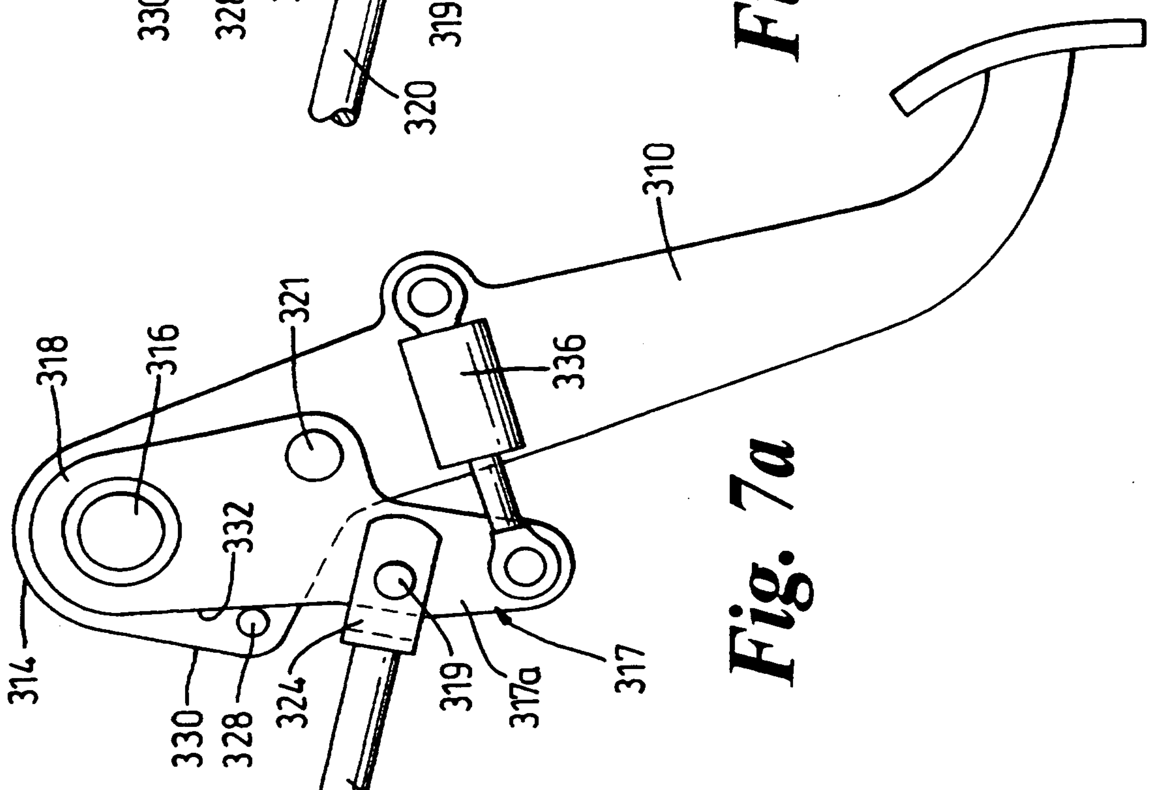

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Fig. 7a

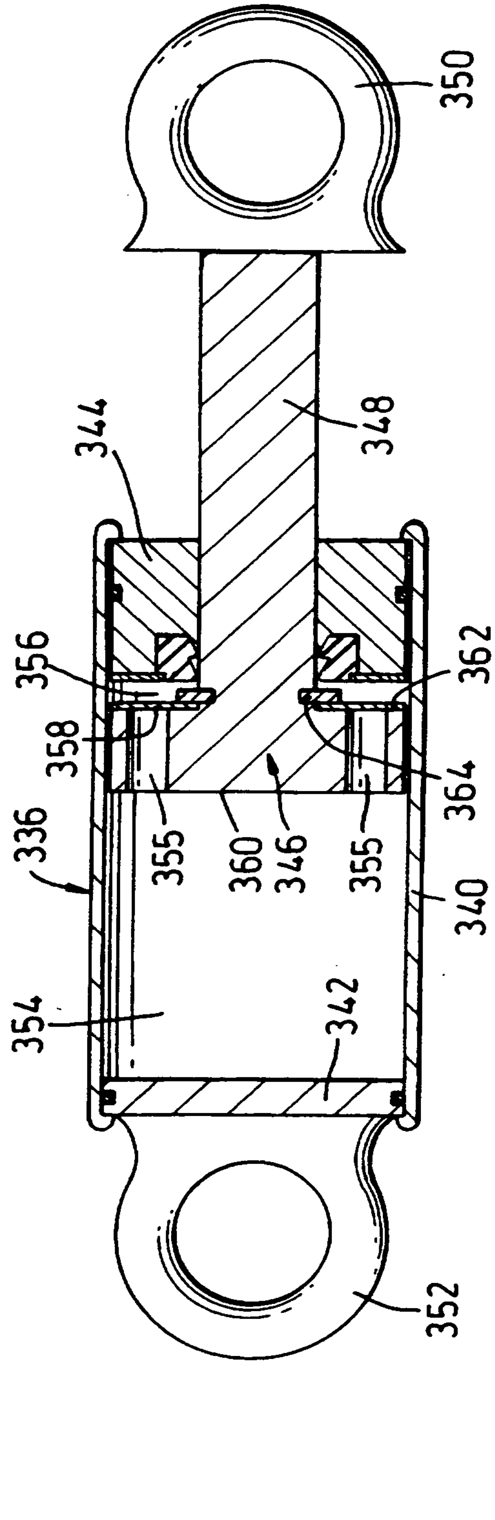

Fig. 8

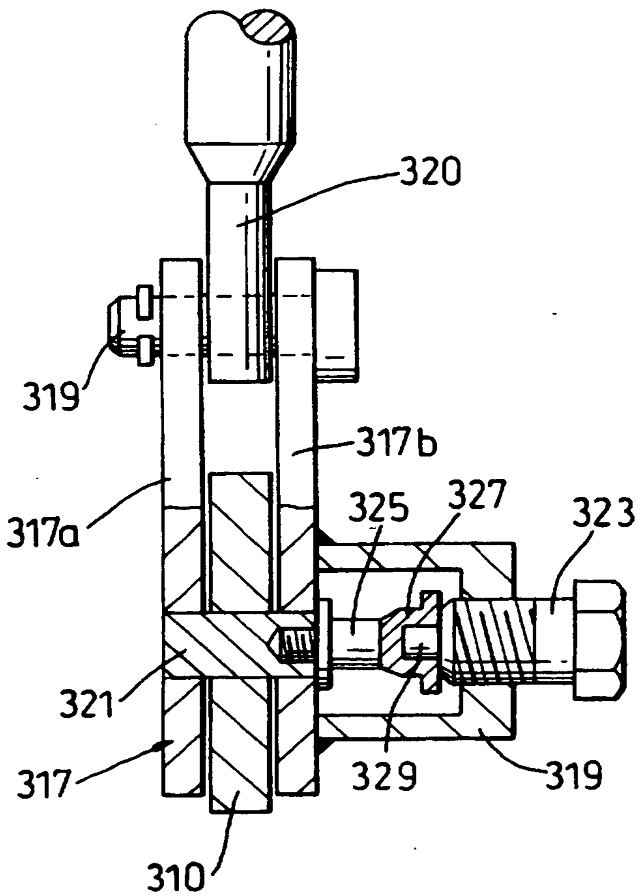

Fig 9

A Vehicle Braking System

The present invention relates to vehicle braking systems and in particular to such systems which include a brake pedal which is arranged to collapse on frontal impact of the vehicle thereby to reduce the chances of the pedal causing injury to the driver.

Various methods have been employed to reduce the damage caused by the brake pedal to the driver in the case of an accident. These include automatic retraction of the brake pedal, as disclosed in GB2031814 and DE 43 40 633, and de-coupling of the brake pedal, as described in DE 195 15 892. However analysis of tests suggests that the freedom of movement of the driver's leg when using these systems can lead to further injury.

It is also known from WO 95/25027 to provide a hydraulic brake actuation system in which a crash sensor is provided which, on detection of an impact, opens a pair of valves to dump brake fluid into a pair of low pressure accumulators through a pair of flow restrictors. This system will provide a light damping force acting against collapse of the brake pedal. This damping force will vary with the speed at which the brake pedal is being depressed and may therefore be significantly higher at higher impact speeds.

DE 19624548 discloses a system in which hydraulic fluid is dumped into an accumulator when the force on the brake pedal exceeds a certain level.

The present invention provides a vehicle brake system comprising a brake for applying a braking force to a wheel of a vehicle, a brake pedal assembly arranged for depression by a driver of the vehicle, and a force transmitting member arranged to be acted on by the pedal assembly to actuate the brake, wherein the pedal assembly includes a pedal member arranged to be operated by a driver's foot and a collapsing mechanism arranged to collapse resiliently to accommodate depression of the pedal member against a controlled resilient force in the event of a frontal impact of the vehicle.

Preferably the collapsing mechanism is arranged to translate the resilient force into an actuating force to actuate the brake.

Preferably the system further comprises locking means for preventing collapse of the collapsing mechanism during normal operation of the brakes, but which can be released to allow such collapse in the event of a frontal impact of the vehicle.

Preferably the collapsing mechanism includes resilient collapsing means which is held under a pre-load when the locking means is operative, and wherein the pedal and the force transmitting member are free to be moved relative to each other by the collapsing means if the locking means is released when the load on the pedal from the driver's foot is less than the pre-load.

Desirably the collapsing mechanism is arranged to collapse only when the depressing force on the pedal exceeds a predetermined limiting value.

Preferably the collapsing mechanism comprises resilient collapsing means arranged to transmit force between the pedal member and the force transmitting member up to said limiting value, and to give when the force on the pedal exceeds said limiting value.

Preferably the collapsing means is held under a pre-load which determines the limiting value.

Preferably the system further comprises stop means which acts against the resilience of the collapsing means to limit relative movement of the pedal member and the force transmitting member in one direction thereby to provide said preload.

Preferably the pedal assembly further comprises a pivoting member arranged to transmit force between the collapsing means and the force transmitting member, and the pivoting member and the pedal member may be arranged to pivot about a common axis.

The force transmitting member may comprise a pushrod such as normally provides the input to a brake servo.

The collapsing mechanism preferably includes damping means so that, on collapse of the brake pedal, it can provide said resilient force and a damping force resisting the collapse.

The present invention further provides a vehicle brake system comprising a brake for applying a braking force to a wheel of a vehicle, a brake pedal arranged for depression by a driver of the vehicle, and a force transmitting means arranged to transmit force applied to the pedal by a driver to apply the brake, wherein the force transmitting means includes a collapsing mechanism arranged to collapse against a controlled force to accommodate depression of the pedal member in the event of a frontal impact and wherein the force provided by the collapsing means can be varied to suit different drivers.

The controlled force may be a damping force or a resilient force.

The system preferably further comprises control means arranged to receive a signal indicative of the weight of the driver and to control the resilient force in response thereto.

The collapsing mechanism preferably comprises a plurality of collapsing means each arranged to provide at least a part of the resilient force, wherein the control means is arranged to select which of the collapsing means is operable to provide the resilient force in response to said signal.

The present invention further provides a vehicle brake system comprising a brake for applying a braking force to a wheel of the vehicle, a brake pedal arranged for depression by a driver of the vehicle, and a hydraulic circuit arranged to actuate the brake when the pedal is depressed, wherein the hydraulic circuit includes accumulating means arranged to receive hydraulic fluid against a controlled force to accommodate depression of the pedal member in the event of a frontal impact of the vehicle.

Preferably the reaction means is arranged to act on fluid received in the accumulating means so as to keep it under pressure, thereby producing the resilient force.

Preferred embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a side view of a brake pedal assembly forming part of a first embodiment of the invention;

Figure 2 is a side view of a brake pedal assembly forming part of a second embodiment of the invention;

Figure 3 is a section through a spring loaded connection mechanism between a brake pedal and a push rod forming part of a fourth embodiment of the invention;

Figure 4 is a side view of a brake pedal assembly forming part of a third embodiment of the invention;

Figure 5 is a section through a hydraulic accumulator mechanism forming part of a fifth embodiment of the invention;

Figure 6 is a section through a hydraulic accumulator mechanism forming part of a sixth embodiment of the invention;

Figures 7a and 7b are side views of a pedal assembly according to a seventh embodiment of the invention;

Figure 8 is a section through a gas strut forming part of the assembly of Figures 7a and 7b; and

Figure 9 is a section through the assembly Figures 7a and 7b.

Referring to Figure 1, in the first embodiment of the invention, a brake pedal 10 is located in the footwell 12 of the passenger compartment of a vehicle. The pedal 10 is pivotably mounted at its upper end 14 on a pivot 16. A pivoting metal plate intermediate member 17 is mounted on the same pivot 16 at its upper end 18 and extends downwards therefrom next to the brake pedal 10. A push rod 20 for actuating a conventional brake servo 22 is pivotably connected to a projection 24 on the front edge 26 of the intermediate member 17. A stop 28 projects sideways from the pedal 10 near its front edge 30, and the intermediate member 17 has an abutment surface 32 on its front edge which is arranged to abut the stop 28. A coil spring 36 has one end attached to the stop 28 and its other end connected to a projection 37 on the rear edge of the intermediate member 17. The coil spring 36 is in tension and holds the abutment surface 32 against the stop 28 with a fixed preload.

Under normal operation when the brake pedal 10 is depressed the preload in the coil spring is sufficient to retain the stop 28 and the abutment surface 32 in contact, so the intermediate member 17 and the pedal 10 move together to move the push rod 20 and actuate the brake system, the coil spring 36 transmitting the force applied to the pedal 10 to the intermediate member 17. If, however, the force applied to the pedal increases to a

threshold force, the force transmitted through the coil spring 36 will increase and become equal to the preload. Increasing the force on the pedal above the threshold force will cause the coil spring 36 to give, allowing the pedal 10 to rotate about the pivot 16 relative to the intermediate member. This collapse of the assembly comprising the pedal 10 and the intermediate member 17 allows the pedal to be depressed a substantial distance against the resilient force of the coil spring 36, beyond the normal displacement allowed by movement of the push rod 20. While the assembly is in the collapsed state the coil spring will remain in tension, which will have two effects. Firstly the force between the pedal 10 and the driver's foot will be maintained at a substantially constant value determined by the strength of the spring 36. Secondly the spring will continue to transmit this force to the pushrod 20 thereby maintaining a level of braking.

When the force applied to the pedal is released, for example when the impact of the vehicle is over, the coil spring will return the pedal 10 and the intermediate member 17 to their original relative positions, with the stop 28 and the abutment surface 32 in contact.

Referring to Figure 2, in the second embodiment of the invention, a brake pedal 50 is pivotably mounted at its upper end 52 on a pivot 54. An intermediate member 56 comprises a plate portion 56a having a slot 56b therethrough and a shaft portion 56c extending from its rear end and a

pivotal connection 58 to a pushrod 60 of a brake servo at its front end. A stop plate 56d is provided at the base of the shaft portion 56c. The intermediate member is positioned next to the pedal 50 which has a boss 62 thereon which extends through the slot 56b. A bracket 64 comprises an end portion 64a at its rearward end having a hole therethrough which fits over the end of the shaft portion 56c of the intermediate member, and a pair of side portions 64b which extend forwards from the end portion and have their free ends 64c attached to the pedal 50, one on either side thereof. A stack of Belleville washers 66 is mounted on the shaft portion 56c of the intermediate member 56 and is compressed between the stop plate 56d and the end portion 64a of the bracket 64. The bracket 64 and pedal 50 can therefore move horizontally relative to the intermediate member 56, the end portion 64a of the bracket 64 sliding along the shaft portion 56c of the intermediate member 56, and the bosses 62 sliding along the slots 56b.

Under normal operation, the Belleville washers urge the intermediate member 56 forwards relative to the bracket 64 and the pedal 50 so that the boss 62 is held against the rearward end of the slot 56b, limiting further relative travel and maintaining the Bellevilles 66 under a preload. The pedal 50, bracket 64 and intermediate member 56 will therefore act as a single unit operating the push rod 60 until the load transmitted between the pedal 50 and the intermediate member 56 through the Bellevilles 66 exceeds the preload in the Bellevilles 66. At that point the Bellevilles 66 will

start to compress, enabling the pedal 50 to move forward relative to the intermediate member 56 against the resilience of the Bellevilles 66. It will be seen that the effect of this arrangement is the same as in the first embodiment, in that the assembly comprising the pedal 50, the bracket 64, the intermediate member 56 and the Bellevilles 66 will collapse when the depressing force applied to the pedal 50 exceeds a specific value, determined by the preload on the Bellevilles 66, while collapsed will maintain a braking force at the brakes of the vehicle and a reactive force between the pedal and the driver's foot on the pedal, and after release of the pedal will return to its original condition.

Referring to Figure 3, in a third embodiment of the invention, the brake pedal is connected to a pushrod 70 by means of a compression capsule 72. The capsule 72 comprises a cylindrical casing 74 having an end wall 76 with an aperture 78 in its centre. A guide member 80 is mounted in the aperture 78 and comprises a connecting portion 82 on the outside of the casing 74, and a cylindrical guide portion 83 extending into the casing 74 through the aperture 78 and having a guide bore 84 in its centre. The end of the pushrod 70 extends into the casing 74 at the opposite end to the guide member 80 and into the guide bore 84, and has a head 86 on it which can slide along the guide bore 84 and is retained therein by a clip 88 located in a groove 90 in the inner surface of the guide bore 84. A circular cap 92 is provided with a central aperture 94 which fits round the push rod 70 and is located at a

position spaced from the end of the push rod by means of flexible tabs 96 on the cap 92 which engage in a groove 98 in the push rod 70. The diameter of the cap 92 is such that it is a sliding fit inside the casing 74. A helical compression spring 100 is held within the capsule 72 with one end against the cap 92 and the other end against the end wall 76 of the casing 74.

Under normal operation the spring 100 urges the push rod 70 and the guide member 80 apart such that the clip 88 engages with the head 86 on the push rod 70, limiting their relative movement and maintaining the spring 100 under a preload. As with the first two embodiments, the spring 100 will give when the load it transmits between the pedal and the push rod 70 exceeds the preload, allowing collapse of the pedal against a resilient force.

Referring to Figure 4, in a fourth embodiment of the invention, a brake pedal 110 is pivotably mounted at its upper end 112 on a pivot 114. An intermediate metal plate pivoting member 116 is mounted at its upper end on the same pivot 114, and has a pivoting connection 118 to a push rod 120 at its front edge and a substantially vertically extending slot 122 through it, close to its rear edge. A metal plate link member 124 has one end, its lower end, attached to the pedal 110 by means of a pivotable connection 126, which is positioned below the pivoting member 116 towards the front edge of the pedal. At its other, upper, end the link member 124 has a boss 128

which projects sideways through the slot 122 such that it can slide along it. A hook 130 projects rearwardly from the upper end of the link member 124, and a similar hook 132 projects from the rear edge of the pedal 110 approximately level with the pivotable connection 126. A coil spring 134 has each end engaged with one of the hooks 130, 132 and urges them apart.

Under normal operation, the coil spring 134 urges the top end of the link member 124 upwards so that the boss 128 is held against the upper end of the slot 122. The engagement of the boss 128 with the top end of the slot 122 limits the relative movement of the pedal 110 and the pivoting member 126 and maintains the spring 134 under a preload. When the pedal 110 is depressed the connection 126 between the pedal 110 and the link member 126 follows an arc around the pivot 114, taking the lower end of the link member 124 with it. This causes the boss 128 on the link member 124 to act against the rear edge of the slot 122 to rotate the pivoting member 116 about the pivot 114 and push the push rod 120 forwards to actuate the brakes. Under normal braking conditions the force of the spring 134 is sufficient to keep the boss 128 at the top of the slot 122. If, however, the force on the brake pedal exceeds a predetermined level the boss 128 will slide down the slot 122 against the resilience of the spring 134. Because the lower end of the slot 122 is approximately the same distance from the pivot 114 as the connection 126, and the upper end of the slot 122 is closer to the pivot, movement of the boss 128 down the slot 122 enables the pedal 110 to

rotate about the pivot 114 relative to the pivoting member 116 against the resilience of the spring 134.

It will be appreciated that the force required on the pedal to move the boss 128 down the slot 122 will depend, among other things, on the strength of the spring 134 and the angle between the front edge of the slot 122 and the link member 124. The front edge of the slot 122 can therefore be shaped to form a cam surface thereby controlling and varying the resistance to relative movement between the pedal 110 and the pivoting member 126 as a function of their relative rotational displacement about the pivot 114. In particular, as shown in this embodiment, the cam surface can include a slight depression 136 in which the boss 128 rests in its normal position. This means that the force required to trigger collapse of the pedal assembly by pulling the boss 128 out of the depression 136 can be set at a level equal to the maximum braking force normally required, whereas the resistance to further movement of the boss 128 along the slot 122 can be set at a lower level.

Referring to Figure 5, in a fifth embodiment of the invention the brakes are hydraulically actuated by a hydraulic brake system which is conventional except that a brake pressure relief unit 150 is interposed between the master cylinder and the slave cylinder. The relief unit 150 comprises a body 151 which has first and second ports 152, 154 in opposite

sides, joined by a passage 156 through which brake fluid flows in each direction during normal operation of the braking system. The body 151 also has a vertical cylindrical bore 158 formed in it which is perpendicular to the passage 156 and has its top end 160 joined to the centre of the passage 156 by a relief port 162. A piston 164 is housed in the bore 158 and comprises a hollow cylinder 166 closed at its top end by an end wall 168 and having a pair of sealing rings 170, one at each end, forming a sliding seal between the piston 164 and the bore 158. The bottom end 172 of the bore 158 is closed by an end piece 174 held in place in the bore by a clip 176 and sealed by a seal 178 around its circumference. The end piece 174 has a hole 180 through its centre with a removable plug 182 in it. The hollow piston 164 is partially filled, over an upper part of its length, with pressurised inert gas, in this case nitrogen gas 184 , and the remaining bottom part of the piston 164 and the bore 158 below the piston, are filled with a liquid 186, in this case silicon ester, which is compatible with brake fluid. The silicon ester 186 contains the nitrogen 184 within the piston 164 and is itself sealed within the bore 158 by the sealing rings 170, 178. A vent 188 is provided through the cylinder wall 190 which forms part of the body 151 and defines the bore 158. The vent 188 is between the two piston sealing rings 170, and is normally closed off by a shrink wrapped plastics tube 192 around the wall 190 of the bore 158. It allows any of the silicon ester, and nitrogen gas, leaking past the lower piston ring 170 to escape in the event of failure of the

sealing rings 170. This prevents the possibility of the gas 184 expanding and forcing brake fluid out of the hydraulic brake circuit which could otherwise happen if the sealing rings 170 failed. It also prevents the silicon ester from escaping past the rings 170 in smaller quantities and mixing with the brake fluid above the piston 164.

The relief port 162 is normally closed off by a stepped cylindrical valve member 194 which has a wide upper portion 194a supported in a valve bore 196 above the passage 156 opposite the relief port 162, and a narrower lower portion 194b which, when the valve member is in its closed position, extends across the passage 156 and closes the relief port 162. A shoulder 194c is formed between the upper and lower portions 194a and 194b of the valve member 194. The upper portion 194a of the valve member 194 abuts at its upper end against a support member 195 which is of greater diameter than the upper portion 194a and located in a correspondingly wider bore 197 above the valve bore 196. A coil spring 198 above the support member 195, and compressed between it and a cover 199 on the top of the bore 197, urges the valve member 194 downwards into its closed position.

The pressure of the gas 184 and the relationship between the inner and outer diameters of the piston 164 are arranged such that the pressure in the brake fluid required to move the piston downwards is about 50 bar. This is sufficient to produce a braking deceleration of the vehicle of about 0.5g.

As mentioned above, during normal operation of the braking system, brake fluid flows through the passage 156 to actuate the brakes. If, however, the depressing force on the brake pedal exceeds a limiting value, and the brake fluid pressure therefore exceeds a corresponding limiting value, or valve opening pressure, the pressure of the brake fluid acting on the shoulder 194c of the valve member 194 will be sufficient to move the valve member upwards against the force of the spring 194 to open the relief port 162. As soon as the valve member 194 is lifted off its seat, the pressure of the brake fluid will act on the whole of the end surface of the lower portion 194b of the valve member 194. This greatly increases the upward force on the valve member for a given brake fluid pressure. Therefore, once the valve member 194 has been moved into its open position it will stay there until the brake fluid pressure drops to a predetermined closing pressure which is lower than the valve opening pressure. When the valve member 194 is in its open position, the piston 164 can move downwards under the pressure of the brake fluid, and against the pressure of the nitrogen 184. The device will therefore act as a high pressure gas accumulator allowing brake fluid to escape from the hydraulic brake system and thereby limiting the force between the driver's foot and the brake pedal and allowing the brake pedal to 'collapse' or be depressed further than would normally be possible. The pressure of the nitrogen 184 will maintain a resilience in the system, urging the piston 164 upwards and thereby

maintaining an upwards force on the brake pedal against the driver's foot, and a pressure in the hydraulic system which will maintain a certain amount of braking while the pedal collapses.

It will be appreciated that, because the valve member 194 will remain open when the brake fluid pressure falls below the initial valve opening pressure, there is considerable freedom in the pressure at which the gas accumulator is set. The limiting force maintained by the accumulator could be higher or lower than the valve lifting pressure. This will determine whether the system provides an initial resistance to collapse which is greater than the force maintained over most the collapsing travel, as described above in the embodiment shown if Figure 4, or whether the resilient force, and hence the limiting force transmitted by the brake pedal, is substantially constant.

The use of a gas accumulator as described allows some compensation for increased fluid viscosity at low temperatures, as the pressure of the gas will decrease with temperature. Also, in the arrangement described, it will be appreciated that the rate of increase of pressure of the nitrogen gas 184 with displacement of the piston 164 can be readily specified by modifying the relationship between the gas volume and the rate at which the liquid 186 is displaced by movement of the piston 164.

In Figure 6, which shows a brake pressure relief unit 250 of a sixth embodiment of the invention, features corresponding to those in the fifth embodiment are indicated by corresponding reference numerals increased by 100. Apart from the differences which will now be described, operation of the sixth embodiment can be considered to be the same as the fifth embodiment.

In the sixth embodiment a solenoid coil 300 is provided under the cover 299 and held up against the under side of the cover 299 by a non-magnetic shim 302 between the cover 299 and the body 251. The support member 295 acts as an armature and can be raised, against the resistance of the spring 298, by passing a current through the coil 300. A control unit 304 is provided which controls the current through the coil 300 in response to a crash sensor 306. Also the valve member 294 is urged downwards relative to the support member 295 by a minor coil spring 308 which is much weaker than the major coil spring 298. Finally, an indicator 310 in the form of a coloured peg is located in a hole through the cover 299. Normally the peg has its upper end flush with the outer surface of the cover 299 and its lower end projecting from the inside of the cover towards the supporting member 295. In the event of actuation of the collapsing mechanism the peg 310 is pushed upwards so that it protrudes from the outer surface of the cover 299. The peg will stay in this position once the supporting member 295 has lowered again, giving an indication that the system has operated.

During normal operation of the braking system the support member 295 is held down by the major spring 298 such that the valve member 294 is in contact with the support member 295 and closes the relief port 262, the minor spring being held in compression between the valve member 294 and the support member 295. If the crash sensor 306 detects a crash, the control unit causes a current to be passed through the coil 300 tending to lift the support member 295 against the resistance of the major spring 298.

If the strength of the solenoid is set high enough it will overcome the force of the spring 298 and raise the support member 295 immediately. The minor spring will then hold the valve member 294 in its closed position until the brake fluid pressure increases above a relatively low limiting pressure, when the valve member 294 will open thus opening the relief port 262. The piston 264 can then move downwards, as in the fifth embodiment, allowing collapse of the brake pedal in the same way. The valve member 294 and minor spring 304 therefore allow control over the pressure required to open the valve when the support member 295 has been raised. Also the raising of the valve member 294 will increase the volume of the hydraulic system and thereby allow a small amount of collapse of the brake pedal against very low resistance.

In the event of failure of the crash sensor, the device will act in the same way as the fifth embodiment, the valve member 294 being raised

when the pressure in the brake fluid reaches a value sufficient to counteract the main spring 298.

As a further alternative it would be possible to omit the minor spring 304. In this case the sixth embodiment would act in a similar manner to the fifth embodiment, except that the power of the solenoid could be set lower so that it was not sufficient to over come the major spring 298. Actuation of the solenoid by the crash sensor would therefore have the effect of lowering the brake fluid pressure required to open the valve.

As a further possible modification, the solenoid 300 could be replaced by a pyrotechnic device. For example the support member 295 could be held in place by a stop which was blown away by a small explosive device upon detection of a crash. The strength of the spring 298 could then be reduced as it would not have to support normal brake pressures during normal operation.

Although the hydraulic units shown in Figures 5 and 6 are shown as independent units it will be understood that they could be incorporated in other units within the hydraulic brake system, such as an ABS unit or the master cylinder. Also it will be understood that, for a brake system having two hydraulic circuits, it would generally be possible to include a brake pressure relief unit in only one of them to minimize costs.

Referring to Figures 7a, 7b, 8 and 9, a seventh embodiment of the invention is similar to the first embodiment, but with replacement of the coil spring by a pair of gas struts 336 and the addition of a pyrotechnic release mechanism which will be described in more detail below. A brake pedal 310 is pivotably mounted at its upper end 314 on a common pivot 316 with an intermediate member 317 which comprises a pair of parallel plate members 317a, 317b one on either side of the pedal 310. The pushrod 320 to the brake servo extends into the gap between the plate members 317a, 317b and is pivotably connected to the intermediate member by a pin 319. The pedal 310 and intermediate member are, under normal operation, locked together by means of a locking pin 321 which extends through aligned holes in both plates 317a, 317b of the intermediate member and the pedal 310. A support housing 319 is mounted on one of the plate members 317b over one end of the locking pin 321 which supports an explosive actuator 323. A plastics shear member 325 is screwed onto the end of the locking pin 321 and a spacer 327 is supported on the actuating pin 329 of the explosive actuator and rests in contact with the shear member 325. On each side of the pedal 310 a gas strut 336 is provided which has one end pivotably attached to the intermediate member 317 at its free end remote from the pivot 316, and its other end pivotably connected to a point on the rear edge of the pedal 310.

Referring to Figure 8 each gas strut 336 comprises a tubular cylinder 340 sealed at one end by a closed end wall 342 and at the other end by an annular end wall 344, and a piston 346 which is arranged to slide in the cylinder 340 and is rigidly attached to one end of a rod 348 which extends through the annular end wall 344 and has a connecting ring 350 attached to its other end. The closed end wall 342 has a similar connecting ring 352 on its outer side. The piston 346 and closed end wall 342 define a working chamber 354 therebetween which is filled with gas under high pressure, and the piston 346 and annular end wall 344 define an annular rear chamber 356 therebetween. The piston 346 has two holes 355 through it from its front face 360 to its rear face 362 connecting the working chamber 354 to the rear chamber 356, and a spring steel washer 358 is held against the rear face 362 of the piston by a circlip 364 located in a groove in the rod 348 so that it covers the rear ends of the holes 355 and acts as a one-way valve.

Under normal operation the pedal 310 and intermediate member 317 are locked together in rotation by the locking pin 321 so the intermediate member 317 and the pedal 310 move together to move the push rod 320 and actuate the brake system, the gas strut 336 being held slightly compressed from its fully extended condition. While the driver's foot is applying a force to the pedal 310 tending to push it forward relative to the intermediate member, that force will tend to counteract the force from the gas strut 336 acting in the opposite direction. Therefore when these forces are

approximately equal the shear forces on the locking pin 321 will be relatively low, allowing it to be removed relatively easily by the actuator 323 as described below.

The explosive actuator 323 is connected to a crash sensor (not shown) and, in the event of a frontal impact of the vehicle, the actuator pin 329 is fired, pushing the shear member 325 and the spacer 327 into the holes in the intermediate member 317 and pedal 310, and the locking pin 321 out of the far side. When the actuator pin 329 has reached the end of its travel the locking pin is pushed out of engagement with the pedal 310 and the shear member 325 rests in that hole through the pedal, and the spacer 327 rests in the hole in the intermediate member. In this state if the force on the pedal 310 is above a predetermined level the shear member will shear allowing the pedal 310 to rotate against the force of the gas struts 336 about the pivot 316 relative to the intermediate member towards the collapsed state shown in Figure 7b. While the assembly is in the collapsed state the gas struts 336 will remain in compression, which will have two effects. Firstly a force will be maintained between the pedal 310 and the driver's foot at a value determined by the strength of the gas struts 336. Secondly the gas struts 336 will continue to transmit this force to the pushrod 320 thereby maintaining a level of braking.

When the force applied to the pedal is released, for example when the impact of the vehicle is over, provided some gas remains in the working chambers 354, the gas struts 336 will tend to expand, returning the pedal 310 and the intermediate member 317 towards their original relative positions, with the stop 328 and the abutment surface 332 in contact. The gas struts 336 provide a damping force as the pedal returns to prevent it from returning too quickly which could cause injury to the driver, for example if his foot had come off the side of the pedal.

The advantage of this arrangement over that shown in Figure 1 is that the gas struts 336 acting between the pedal 310 and intermediate member 317 can be of a significantly lower rate than the spring shown in Figure 1, firstly because they do not have to support normal operation of the brake pedal, and secondly because there are two of them.

Gas struts of the type illustrated can be modified in many ways to tune the resistance they will produce to collapse of the brake pedal. For example, in a modification of the arrangement shown in Figures 7 to 9, the gas struts can be arranged substantially vertically with the piston at the lower end and can have some oil in the working chamber as well as gas. When the strut is being compressed during collapse the damping resistance over a first portion of travel, while the oil flows out through the piston, will be

relatively high, and thereafter the resistance will be lower because the gas can flow through the hole in the piston more easily.

In a further modification of the version shown in Figures 7 to 9 the pyrotechnic actuator could be deleted and the locking pin replaced by a shear pin which would simply shear when the load in the pedal exceeds a predetermined level. The load required to shear the shear pin would preferably be set higher than the resilient load of the gas struts to provide a high initial resistance to collapse.

In a further modification a further pyrotechnic actuator is provided in the link between one of the gas struts and either the pedal or the intermediate member, the actuation of which is dependent on the weight of the driver which can be determined by a simple sensor in the driver's seat. This type of sensor is already used in connection with airbag systems. Provided the driver is above a predetermined weight the system operates as described above. If, however, the driver's weight is below the predetermined weight, in the event of an impact sensed by the crash sensor both of the pyrotechnic actuators are fired. This releases the mechanism to allow it to collapse, but also disconnects one of the gas struts to that the force resisting collapse is reduced. The flexibility this provides could be extended further by having the two struts of different spring rates with each of them being selectively dis-connectable. This would give three possible spring rates

depending on whether one or the other or both of the struts was kept connected during collapse.

In yet a further modification of the embodiment of Figures 7 to 9, the gas strut is held under a pre-load and the shear member 325 is either arranged to have a very low resistance to shear or is effectively deleted altogether, and the stop 328 is deleted so that, when the locking pin 321 is removed on a frontal impact of the vehicle the pedal 310 is free to move upwards towards the driver and away from the floor and the firewall of the driver's compartment, or, if the driver is holding his foot firmly enough in place on the pedal, the intermediate member 317 is free to move downwards to increase the braking force or at least take up slack in the braking system.

CLAIMS

1. A vehicle brake system comprising a brake for applying a braking force to a wheel of a vehicle, a brake pedal assembly arranged for depression by a driver of the vehicle, and a force transmitting member arranged to be acted on by the pedal assembly to actuate the brake, wherein the pedal assembly includes a pedal member arranged to be operated by a driver's foot and a collapsing mechanism arranged to collapse resiliently to accommodate depression of the pedal member against a controlled resilient force in the event of a frontal impact of the vehicle.

2. A system according to claim 1 wherein, in its collapsed state, the collapsing mechanism is arranged to translate the resilient force into an actuating force to actuate the brake.

3. A system according to claim 1 or claim 2 further comprising locking means for preventing collapse of the collapsing mechanism during normal operation of the brakes, but which can be released to allow such collapse in the event of a frontal impact of the vehicle.

4. A system according to claim 3 wherein the collapsing mechanism includes resilient collapsing means which is held under a pre-load when the locking means is operative, and wherein the pedal and the force transmitting member are free to be moved relative to each other by the

collapsing means if the locking means is released when the load on the pedal from the driver's foot is less than the pre-load.

5. A system according to any foregoing claim wherein the collapsing mechanism is arranged to collapse only when the depressing force on the pedal exceeds a predetermined limiting value.

6. A system according to claim 5 wherein the collapsing mechanism comprises resilient collapsing means arranged to transmit force between the pedal member and the force transmitting member up to said limiting value, and to give when the force on the pedal exceeds said limiting value.

7. A system according to claim 6 wherein the collapsing means is held under a pre-load which determines the limiting value.

8. A system according to claim 7 further comprising stop means which acts against the resilience of the collapsing means to limit relative movement of the pedal member and the force transmitting member in one direction thereby to provide said preload.

9. A system according to claim 8 wherein the pedal assembly further comprises a pivoting member arranged to transmit force between the collapsing means and the force transmitting member.

10. A system according to claim 9 wherein the pivoting member and the pedal member are arranged to pivot about a common axis.

11. A system according to any foregoing claim wherein the force transmitting member comprises a pushrod.

12. A system according to any foregoing claim wherein the collapsing means comprises a spring strut.

13. A system according to any foregoing claim wherein the collapsing mechanism includes damping means so that, on collapse of the brake pedal, it can provide said resilient force and a damping force resisting the collapse.

14. A system according to claim 13 wherein the collapsing mechanism comprises a gas strut including a gas spring for providing the resilient force.

15. A system according to claim 13 or claim 14 wherein the damping means is and a hydraulic damper.

16. A system according to any foregoing claim wherein the resilient force provided by the collapsing means can be varied to suit different drivers.

17. A vehicle brake system comprising a brake for applying a braking force to a wheel of a vehicle, a brake pedal arranged for depression by a driver of the vehicle, and a force transmitting means arranged to transmit force applied to the pedal by a driver to apply the brake, wherein the force transmitting means includes a collapsing mechanism arranged to collapse against a controlled force to accommodate depression of the pedal member in the event of a frontal impact and wherein the force provided by the collapsing means can be varied to suit different drivers.

18. A system according to claim 17 wherein said controlled force is a damping force.

19. A system according to claim 17 wherein said controlled force is a resilient force.

20. A system according to claim 17 or claim 19 further comprising control means arranged to receive a signal indicative of the weight of the driver and to control the resilient force in response thereto.

21. A system according to claim 20 wherein the collapsing mechanism comprises a plurality of collapsing means each arranged to provide at least a part of the resilient force, wherein the control means is arranged to select which of the collapsing means is operable to provide the resilient force in response to said signal.

22. A system according to claim 21 wherein the control means is arranged to disconnect one or more of the collapsing means to reduce the resilient force if the drivers weight is below a predetermined threshold.

23. A vehicle brake system comprising a brake for applying a braking force to a wheel of the vehicle, a brake pedal arranged for depression by a driver of the vehicle, and a hydraulic circuit arranged to actuate the brake when the pedal is depressed, wherein the hydraulic circuit includes accumulating means arranged to receive hydraulic fluid against a controlled force to accommodate depression of the pedal member in the event of a frontal impact of the vehicle.

24. A system according to claim 23 wherein the accumulating means includes resilient reaction means to provide the controlled force.

25. A system according to claim 24 wherein reaction means is arranged to act on fluid received in the accumulating means so as to keep it under pressure, thereby producing the resilient force.

26. A system according to claim 25 wherein the reaction means comprises a piston and biasing means acting on the piston.

27. A system according to claim 26 wherein the biasing means comprises a gas spring.

28. A system according to claim 27 wherein the biasing means further comprises support means which supports the piston defines therewith a cavity in which the gas is contained.

29. A system according to claim 28 wherein the biasing means further comprises a liquid which fills a part of said cavity such that the gas is confined wholly by the liquid and one of the piston and the supporting means.

30. A system according to any one of claims 25 to 29 further comprising stop means arranged to act against the biasing means to limit movement of the piston thereby to maintain the biasing means under a preload which determines the limiting value.

31. A system according to any one of claims 23 to 30 further comprising a valve movable between an open position wherein it allows the flow of hydraulic fluid between the actuating system and the accumulating means, and a closed position wherein it prevents such flow.

32. A system according to claim 31 wherein the valve is arranged to be opened by the pressure of hydraulic fluid in the actuating system when that pressure exceeds a predetermined opening pressure.

33. A system according to claim 32 wherein the valve is arranged to be held open by the pressure of the hydraulic fluid until that pressure drops to a closing pressure which is lower than the opening pressure.

34. A system according to any one of claims 31 to 33 further comprising valve opening means and impact detection means wherein the impact detection means is arranged to actuate the valve opening means if it detects an impact with the vehicle.

35. A system according to any one of claims 23 to 34 further comprising indicating means arranged to provide an indication that the accumulating means has operated.

36. A system according to claim 35 wherein the indicator means comprises a movable member arranged to be moved from a first position to a second position by operation of the collapsing means.

37. A braking system substantially as hereinbefore described with reference to any one of the accompanying drawings.

The Patent Office

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Application No: GB 9804031.4
Claims searched: 1 - 16

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): B7B (BEXB BSDA) F2Y(YSF YSX)

Int Cl (Ed.6): B60R 21/00, B60T 7/00 7/02 7/04 7/06 15/00 15/02 17/18

Other: ONLINE: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	WO 95/32115 A1 ALLIEDSIGNAL - FIG 1	1 at least
X	WO 95/25027 A1 AUTOMOTIVE EUROPE - FIG 1	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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